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(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Kazuomi SAKATANI

Application No.: 09/707,837

Art Unit: 2625

Filed: November 8, 2000

Examiner: Christopher T. Sukhaphadhana

For: IMAGE ERROR DIFFUSION DEVICE WITH NOISE SUPERPOSITION (as amended)

SUBMISSION OF VERIFIED TRANSLATION OF FOREIGN PRIORITY DOCUMENT

MS Non-Fee Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

This application claims priority under 35 USC 119 to Japanese patent application no. H11-319075, filed November 10, 1999. Pursuant to 35 USC 119, a certified copy of said patent application was submitted on November 8, 2000, thereby perfecting the priority claim.

In support of the Applicant's claim for priority, filed herewith is a verified translation of the above-identified priority document.

It is respectfully requested that the receipt of the document attached hereto be acknowledged in this application.

In the event the U.S. Patent and Trademark office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and

authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to Deposit Account No. 03-1952 referencing docket no. 325772019900.

Dated: February 2, 2004

Respectfully submitted,

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VERIFICATION OF TRANSLATION

I, Takashi Kamada, 1-1-2, Tokiwa-Cho, Sakai-Sity, Osaka, Japan, hereby declare that I am conversant with the English and Japanese languages. I further declare that to the best of my knowledge and belief the following is a true and correct translation of Japanese Patent Application No.H11-319075.

Date: January 21, 2004

T. Kamada

Takashi Kamada

[Title of the Document]	Patent Application
[Reference Number]	TB12192
[Application Date]	November 10th, 1999
[Direction]	Commissioner, Patent Office
[Classification of International Patent]	H04N 1/46
[Title of the invention]	IMAGE PROCESSING DEVICE
[Number of claims]	6
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[Prepayment Registration Number]	010995
[Filing Fee]	21,000
[List of Enclosures]	
[Document]	Specification 1
[Document]	Drawing 1
[Document]	Abstract 1
[Power of Attorney/Reference No.]	9716123
[Necessary or Unnecessary of Proof]	Necessary

<LT>

Specification

Color conversion apparatus

What Is Claimed Is:

1. A color conversion apparatus that has an error adding unit that corrects the color of each pixel of an input image in accordance with error data, an output color selector that converts the color corrected by said error adding unit into a single color selected from among multiple outputtable colors based on a preset principle, and an error calculator that creates data used for diffusion of color errors that occur during conversion by said output color selector into the pixels peripheral to a target pixel and supplies this data as said error data to said error adding unit, wherein a noise overlay unit that overlays noise onto said input image is disposed as a front end to said error adding unit.

2. A color conversion apparatus that has an error adding unit that corrects the color of each pixel of an input image in accordance with error data, an output color selector that converts the color corrected by said error adding unit into a single color selected from among multiple outputtable colors based on a preset principle, and an error calculator that creates data used for diffusion of color errors that occur during conversion by said output color selector into the pixels peripheral to a target pixel and supplies this data as said error data to said error adding unit, wherein a noise overlay unit that overlays noise onto the image corrected by said error adding unit is disposed as a front end to said output color selector.

3. The color conversion apparatus according to Claim 2, wherein said error adding unit generates said error data based on the difference between the output from said error adding unit before said noise overlay and the output from said output color selector.

4. The color conversion apparatus according to any of Claims 1 through 3, wherein the color of each pixel of the input image is converted into an outputtable color using the vector error diffusion method in which color is handled as a vector.

5. The color conversion apparatus according to Claims 1 or 2, wherein said noise is color data having a certain relationship to the colorimetric value of said outputtable color.

6. The color conversion apparatus according to Claim 5, wherein said noise is selected such that total sum of the relative amounts for the colorimetric values of said outputtable colors is zero.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Field of the Invention

The present invention relates to a color conversion apparatus that uses the error diffusion method.

Description of the Related Art

The error diffusion method is used where multiple tone images are to be output by a binary printer, or where a given amount of data is to be reduced for subsequent storage or transmission. Normally, for full-color images, device-dependent signals such as CMYK or RGB signals are independently thinned, and full-color images are quasi-reproduced by synthesizing these signals when they are output (or displayed).

However, the colorimetric values for each output color depend on the device. Furthermore, when halftone expression is performed using the same output apparatus, differences in color will be observed when the degree of overlapping among the CMYK dots is different even if the density of the dots of each color stays the same. Because in general color error diffusion, input signals that vary depending on the device are used, and the problem of dot overlap for the same pixel is not taken into account, it is difficult to improve color reproducibility.

Accordingly, a method has been proposed in which halftone processing based on error diffusion is carried out using a color vector space (Japanese Laid-Open Patent Application H9-307776). In this method, the input image data is handled as a multidimensional quantity rather than as a unidimensional quantity. While device-dependent color signals can be used as vector color signals, in theory, the input and output colors can be expected to match colorimetrically if the halftone processing is performed in the following manner using input images expressed in a uniform, non-device dependent color space such as XYZ or CIELAB, as well as the XYZ values or CIELAB values for the colors that can be output by an output apparatus known in advance (in the case of a binary device, the eight colors of cyan, magenta, yellow, red, green, blue, white and black, with the colorimetric value of the paper itself often being used for white).

(1) To determine an output color, 'compare the input color (vector) and outputtable colors (vectors) and select the color with the smallest difference (vector) between the two', i.e., 'select the outputtable color that is closest to the input color within the color space'.

(2) Calculate the error between the input color and the output color that occurs during color selection.

(3) For a non-processed pixel, correct the input color via weighted addition of the errors generated for peripheral pixels that have already been processed, and then carry out the operation of step (1) for the non-processed pixel.

This method is also called the vector error diffusion method, and permits highly accurate color reproduction using a relatively small number of colors. It also accommodates an increase in the number of outputtable colors due to multiple-level gradation or the addition of spot colors.

SUMMARY OF THE INVENTION

However, the conventional color conversion apparatus that carries out image thinning via the error diffusion method suffers from the drawback that, because the number of selectable output colors is small, texture noise consisting of the periodic appearance of a certain selected color occurs, resulting in the problem that the visual impression (graininess) of the image declines dramatically.

An object of the present invention is to increase the quality of output images by reducing periodic noise among color components.

MEANS TO RESOLVE THE ISSUES

In the present invention, the method to intentionally superpose noise on the image data, which is known as a method for reducing graininess, is applied to the image thinning carried out via the error diffusion method.

The apparatus of the invention according to Claim 1 is a color conversion apparatus that has an error adding unit that corrects the color of each pixel of an input image in accordance with error data, an output color selector that converts the color corrected by the error adding unit into a single color selected from among multiple outputtable colors based on a preset principle, and an error calculator that creates data used for diffusion of color errors that occur during conversion by the output color selector into the pixels peripheral to a target pixel and supplies this data as the error data to the error adding unit, wherein a noise overlay unit that overlays noise onto said input image is disposed as a front end to the error adding unit.

In the color conversion apparatus according to Claim 2, a noise overlay unit that overlays noise onto the image corrected by the error adding unit is disposed as a front end to the output color selector.

In the color conversion apparatus according to Claim 3, the error adding unit generates the error data based on the difference between the output from the error adding unit before the noise overlay and the output from the output color selector.

In the color conversion apparatus according to Claim 4, the color of each pixel of the input image is converted to an outputtable color using the vector error diffusion method in which color is handled as a vector.

In the color conversion apparatus according to Claim 5, the noise is color data having a certain relationship to the colorimetric value of the outputtable color.

In the color conversion apparatus according to Claim 6, the noise is selected such that the total sum of the relative amounts for the colorimetric value of each outputtable color is zero.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Fig. 1 is block diagrams showing examples of the construction of a color conversion apparatus.

The respective color conversion apparatuses 1, 2 and 3 shown in Figs. 1(a) through 1(c) are means for image thinning performed for the purposes of printing, display and/or storage, and are incorporated in a computer system or a color printer. In the respective color conversion apparatuses 1, 2 and 3, the periphery error adding units 11, 21 and 31, the output color selectors 12, 22 and 32 and the error calculators 13, 23 and 33 are basic constituent components involved in color conversion using the vector error diffusion method. The noise overlay units 14, 24 and 34 represent an additional constituent component unique to the present invention.

Because the functions of the individual constituent components are essentially identical for the three color conversion apparatuses 1, 2 and 3, the basic elements of the error diffusion routine will be described here using the color conversion apparatus 1 shown in Fig. 1(a) as a representative example.

In the color conversion apparatus 1, from input to output, images are handled as data in a CIELAB color space (however, they may consist of multidimensional data in a different color space, such as the XYZ color space or the CIELCH color space).

The input image G1 is processed sequentially on a pixel-by-pixel basis in the direction of raster scanning. The periphery error adding unit 11 corrects data for a target pixel belonging to the input image G1 in accordance with the error data D13 from the error calculator 13. The error data D13 constitutes, of the weighted color conversion errors for previously processed pixels that were distributed to peripheral pixels, the parts allocated to the target pixel. A weighting matrix (also called a 'diffusion matrix') not shown is used for error distribution, and errors are distributed to the target pixel from multiple pixels within the matrix. Therefore, the error data D13 is the sum of distributed errors regarding multiple pixels. The error calculator 13 sequentially adds the distributed error value for each pixel and stores the sum. The output color selector 12 selects, for the target pixel corrected by the error adding unit 11, one output color option (outputtable color) based on the principle of 'select the color closest to the input color within the color space,' for example. The output image G12 is reproduced using the selected output color . In this example, the output apparatus that performs image reproduction is a binary color printer, and there are eight outputtable colors (cyan (C), magenta (M), yellow (Y), red (R), green (G), blue (B), white (W) and black (K)). When an output color is to be selected, the principle of 'after a simple comparison of the target color vector V and each output color vector Vi, select the color having the smallest difference vector $|V - Vi|$ (i.e., the color closest to the input color in the color space)' is applied. Using this principle, however, because the color of pixels adjacent to the target pixel affects the area of the target pixel, the actually observed target pixel color may differ from the output color vector Vi. If the observed color is deemed Vi', a more appropriate principle would be select the color resulting in the smallest difference vector $|V - Vi'|$'.

A noise overlay unit 14 is disposed in the color conversion apparatus 1 as a front end of the periphery error adding unit 11. The noise overlay unit 14 overlays a noise component described below over the input image G1 in order to minimize color texture having a color component imbalance. Proper selection of noise enables output image graininess to be improved without a loss of color tone.

In the color conversion apparatus 2 shown in Fig. 1(b), a noise overlay unit 24 disposed as a front end of the output color selector 22 superposes noise over the output of the periphery error adding unit 21. The error calculator 23 generates error data D23 in accordance with the difference between the pixel color represented by the output from the noise overlay unit 24 and the pixel color of the output image G22 and supplies this data to the periphery error adding unit 21. In the color conversion apparatus 3 shown in Fig. 1(c) also has a noise overlay unit 34 disposed as a front end to the output color selector 32, as with the color conversion apparatus 2, and noise is superposed over the output from the periphery error adding unit 31. The color conversion apparatus 3 is characterized in that the error calculator 33 generates error data D33 in accordance with the difference between the pixel color represented by the input to the noise overlay unit 34 and the pixel color of the output image G32. The error data D33 is supplied to the periphery error adding unit 31. Color tone can be maintained via noise selection in the color conversion apparatuses 2 and 3 as well.

Fig. 2 shows an example of intentionally overlaid noise. Here, the target of noise overlay is an L*a*b* color space, and the outputtable colors are C, M and Y.

If the colorimetric values of the outputtable colors C, M and Y (i.e., the L* value, a* value and b* value) are known, color component texture generation within a uniform patch image area can be inhibited by superposing noise having a Gaussian distribution centered around these values. Moreover, the color tone of the entire image is maintained if the total sum of the relative amounts of overlay noise for the colorimetric value of each outputtable color is made zero.

Fig. 3 shows another example of intentional overlay noise. Here, the noise is overlaid in an L*C*h* color space, and the outputtable colors are C, M and Y.

The color tone of the entire image is maintained in an L*C*h* color space as well if the total sum of the relative amounts of overlay noise for the colorimetric value of each outputtable color is made zero.

Because the noise is overlaid in an L*a*b* color space or an L*C*h* color space according to the present embodiment, quantitative image quality evaluation that accommodates human perception can be achieved, and the overlay noise can be effectively optimized.

In the above embodiment, the noise parameters (noise amount, distribution) can be modified in accordance with the resolution of the output apparatus, such as a printer, and the

image attributes (text area, photo image area, or the like). The noise can also be modified on a pixel-by-pixel basis. Alternatively, the principle governing output color selection need not be a single fixed rule, and multiple rules may be selectively used in accordance with the nature of the input image or the use to which the output image is to be put.

EFFECT OF THE INVENTION

According to the invention described in Claims 1 through 6, the colors of input images can be reproduced with high accuracy using a small number of colors, and the image quality of the output image can be improved by reducing the periodic color component noise.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is block diagrams showing examples of the construction of a color conversion apparatus;

Fig. 2 shows an example of the intentional overlay of noise; and

Fig. 3 shows another example of the intentional overlay of noise.

Symbols

1-3 Color conversion apparatus

G1 Input image

D13, D23, D33 Error data

11, 21, 31 Periphery error adding unit (error adding unit)

12, 22, 32 Output color selector

13, 23, 33 Error calculator

ABSTRACT OF THE DISCLOSURE

Periodic color component noise is decreased and output image quality is improved.

In a color conversion apparatus 1 that uses the error diffusion method and has an error adding unit 11 that corrects the color of each pixel of an input image G1 in accordance with error data, an output color selector 12 that converts the color corrected by the error adding unit 11 into a single color selected from among multiple reproducible colors in accordance with a preset principle, and an error calculator 13 that creates data D13 used for diffusing the color error generated during the conversion by the output color selector 12 into pixels peripheral to the target pixel, and give the data D13 to the error adding unit 11, a noise overlay unit 14 is used to overlay noise onto the input image G1 is included.

Selected drawing: Fig. 1

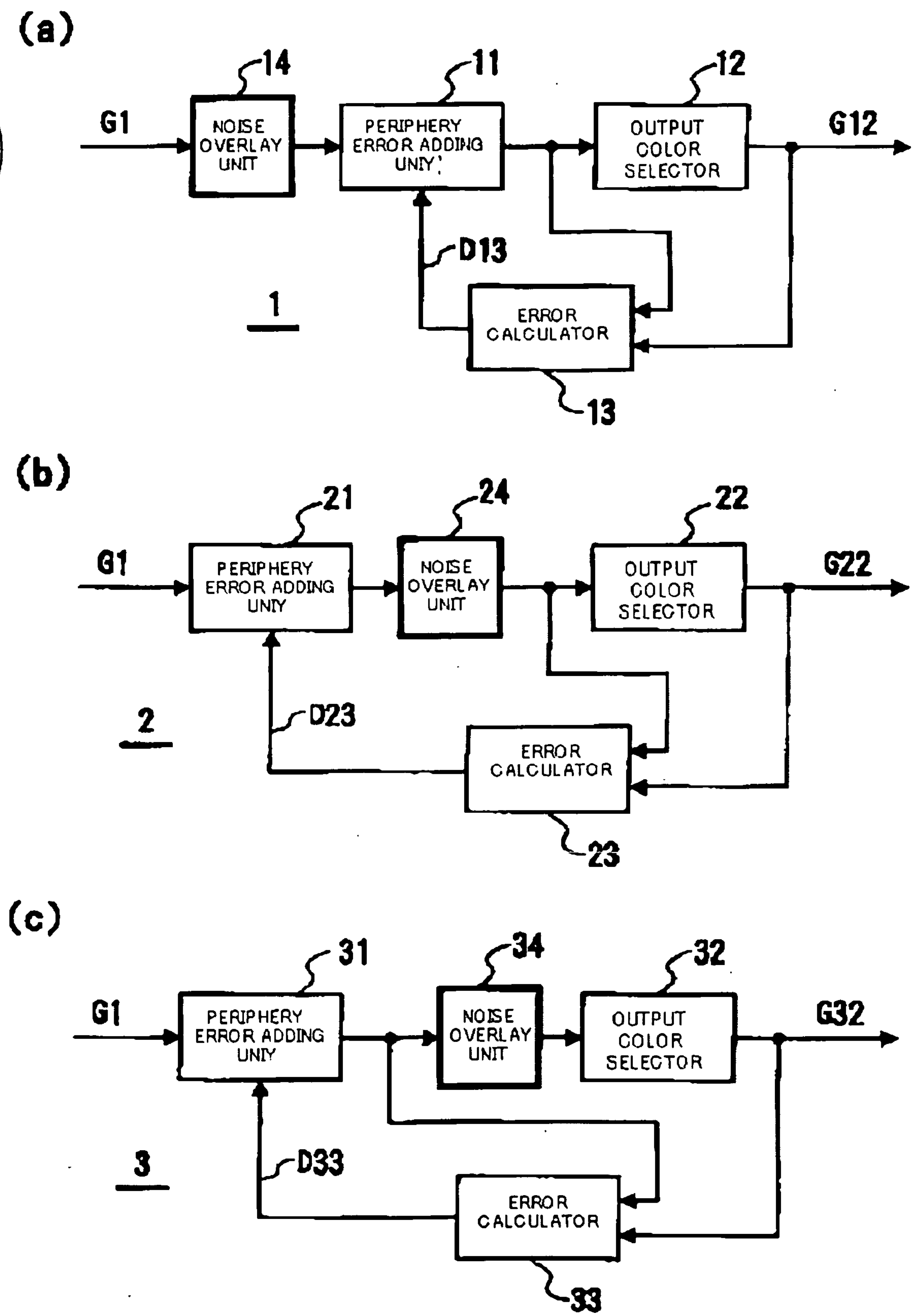
(a)
14
11
12
G1
NOISE OVERLAY UNIT
PERIPHERY ERROR ADDING UNIT
OUTPUT COLOR SELECTOR
G12
D13
1
ERROR CALCULATOR
13
(b)
21
24
22
G1
PERIPHERY ERROR ADDING UNIT
NOISE OVERLAY UNIT
OUTPUT COLOR SELECTOR
G22
D23
2
ERROR CALCULATOR
23
(c)
31
34
32
G1
PERIPHERY ERROR ADDING UNIT
NOISE OVERLAY UNIT
OUTPUT COLOR SELECTOR
G32
D33
3
ERROR CALCULATOR
33

FIG. 1

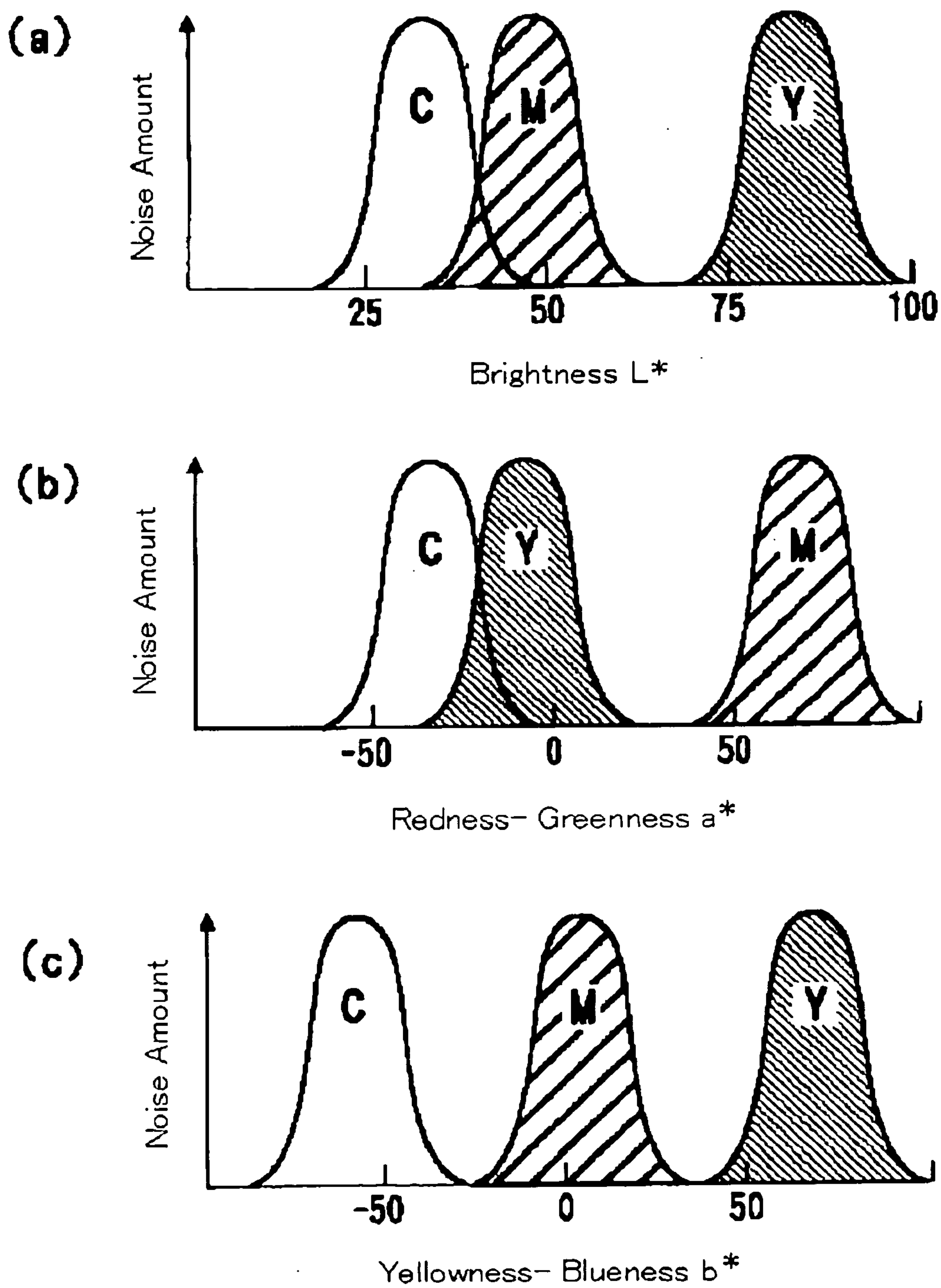
(a)
Noise Amount
C
M
Y
25
50
75
100
Brightness L*
(b)
Noise Amount
C
Y
M
-50
0
50
Redness- Greenness a*
(c)
Noise Amount
C
M
Y
-50
0
50
Yellowness- Blueness b*

FIG. 2

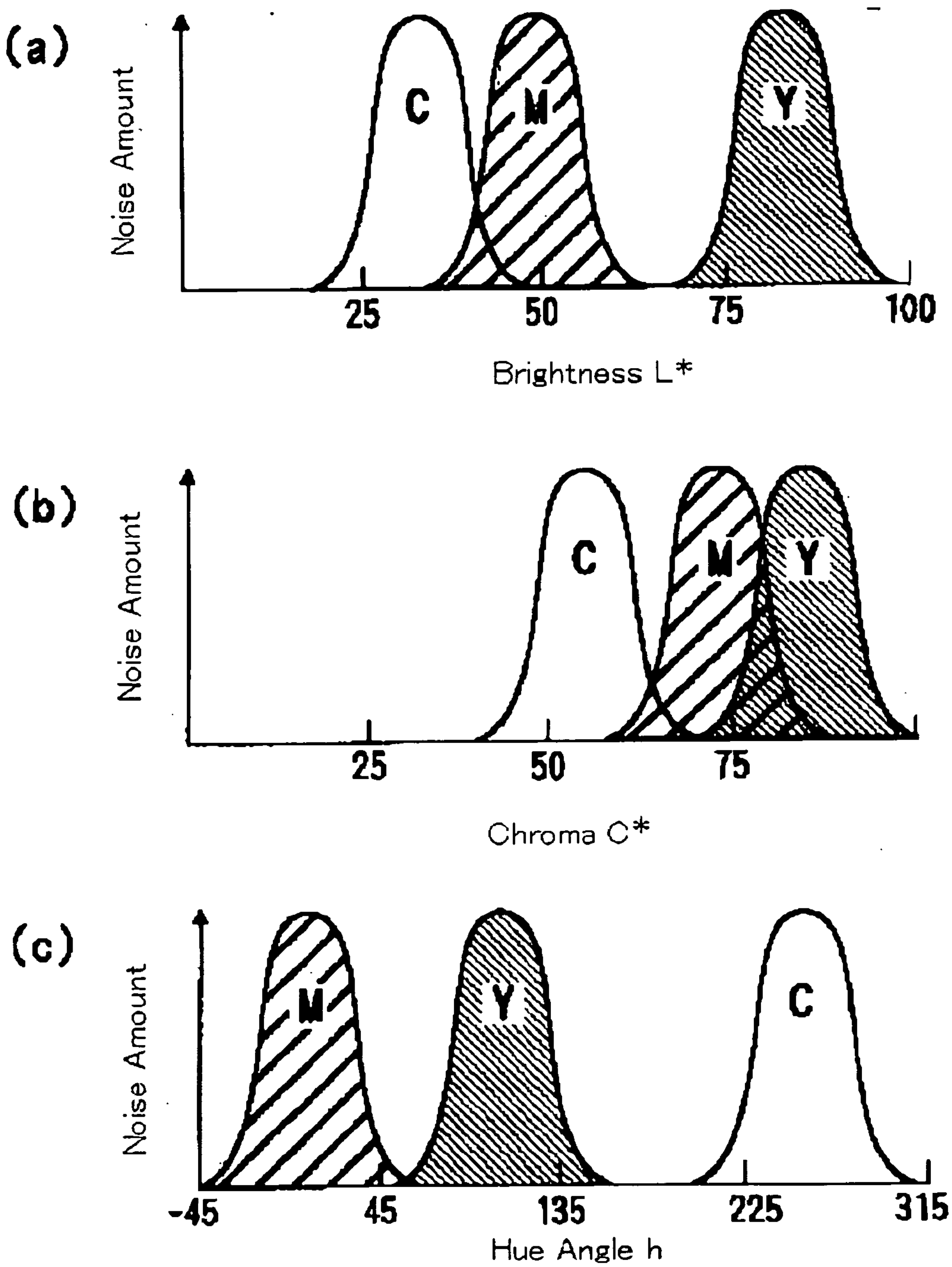
(a)
Noise Amount
C
M
Y
25
50
75
100
Brightness L*
(b)
Noise Amount
C
M
Y
25
50
75
Chroma C*
(c)
Noise Amount
M
Y
C
-45
45
135
225
315
Hue Angle h

FIG. 3